No. 0092-02-05

Guidelines for Highway Shoulder Performance

putting research to work

BRIEF

RESEARCH DEVELOPMENT & TECHNOLOGY TRANSFER

What's the Problem?

WisDOT currently possesses little data on the performance of concrete and asphalt shoulders abutting Portland cement concrete mainline pavements, and so lacks adequate means to determine the best design choices for these shoulders.

Furthermore, maintenance crews report poor performance by shoulders. Heaving and other distresses impede snow removal operations and wear plow blades unevenly. Premature cracking forces maintenance crews to rehabilitate relatively new shoulders. This constant maintenance demand exposes crews to high volume traffic and safety hazards.

District maintenance staff want shoulder designs that eliminate or heavily reduce crew exposure and cold weather problems on heavy volume roadways like Interstates. Such designs cannot be formulated without clearer understanding of performance characteristics and costs associated with various shoulder design options.

Research Objectives

This research seeks to fill the data void and design uncertainty related to shoulders adjacent to concrete pavements. Specific objectives include:

1. Develop performance optimizing guidelines for selection, design and construction of shoulders adjacent to concrete pavements;
2. Determine cost effectiveness of paved shoulders; and
3. Broaden current WisDOT knowledge of design, construction, performance, cost and maintenance of shoulders along concrete pavements.

Research Methodology

Researchers aimed to accomplish the task through the following steps:

1. Literature review and survey of design, construction, and maintenance practices, as well as costs and performance, in Wisconsin and six surrounding states;
2. Selection and review of Wisconsin shoulder types;
3. Survey of shoulder conditions on 289 miles of roadway at 133 sites in Wisconsin;
4. Analysis of survey results and site conditions for impact of various design factors;
5. Development of new guidelines for shoulders abutting concrete pavements.

Research Results

A literature review and surveys of other states showed that WisDOT stands in a crowd of state DOTs that lack clear design and performance data for shoulders abutting concrete pavements, that struggle with premature stresses on shoulders, and that face increasing shoulder uses such as diverted traffic during mainline maintenance. States generally agree that concrete shoulders should be jointed plain concrete tied to the mainline, and that formal shoulder maintenance programs and intra-agency communication channels are needed.

Concrete shoulders generally suffer slab breakup, distressed joints, and longitudinal stress; and these distresses were directly affected by shoulder base thickness. Asphalt pavements suffer a variety of cracking forms, edge raveling, heave, settlement, and longitudinal joint deterioration; and shoulder width and thickness and aggregate base types impacted these stresses. Shoulders alongside doweled, jointed concrete pavements showed significantly less stress than those alongside non-doweled concrete.

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Longitudinal joint deterioration severity level 2, Figure G-12.

Modeling of distress modes in shoulder types adjacent to concrete pavement requires a shift from traditional combination indices including Pavement Distress Index (PDI) and Pavement Condition Index (PCI), which produce average distress figures for various combinations, but fail to describe the specific stress effects of interest to design evaluation. This study produced a Shoulder Distress Index Factor (SDIF) that combined extent and severity of each type of stress effect for different shoulder-pavement combinations, yielding data useful for design considerations.

"This study gives us our first systematic look at the performance of highway shoulders. We're looking closely at the suggested guidelines for ways to improve both construction and maintenance of shouders. "

- David Larson, WisDOT Pavements Section

Design guidelines for concrete shoulders include:

- Increase shoulder minimum base thickness to 10 inches or more.
- Investigate appropriate bar height for rumble strips, the site of most slab breakup.

Design guidelines for asphalt shoulders include:

- Minimum width of eight feet for asphalt shoulders or shoulder components in composite shoulders (those with concrete bordered by asphalt).
- Filling of longitudinal joints between concrete and asphalt.
- Use of crushed aggregate base course.
- Increase minimum surface thickness to four inches.

Changes in shoulder types and designs require life cycle cost analysis. In the case of concrete, this is particularly important for considering pavement thickness greater than 10 inches; in asphalt, minimum width and surface thickness both should be informed by such analysis, in order to assure that the increased construction cost will be balanced by reduced maintenance expense. Furthermore, researchers asserted WisDOT needed a coherent department policy regarding sealing of all longitudinal joints.

Benefits Anticipated

By implementation of the above design guidelines, WisDOT should experience extended performance life for shoulders that will experience less severe stresses. Hence, less maintenance will be required, and maintenance costs and safety risks will both diminish.

Future Research Directions

The investigators recommended further research focused on performance monitoring and mainline-shoulder design interactions.

Specific research directions proposed include:

1. Investigation of use of same material for both pavement and shoulder, which could reduce construction and maintenance costs and improve performance.
2. Exploration of automated data collection systems for shoulders.
3. Development of a database system for design, construction, maintenance and performance for holistic pavement systems that include both mainline and shoulders.
4. Creation of formal communication procedures between design, construction and maintenance units impacted by shoulder performance.
5. Establishment of performance and maintenance goals for shoulders of various highway classifications.
6. Exploration of reducing concrete pavement thicknesses for pavements tied to concrete shoulders; researchers speculate that well-designed concrete shoulders could provide edge support sufficient to accommodate an inch reduction in mainline thickness.

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Performance of Shoulders Adjacent to Concrete Pavements

0092-02-05

June 2003

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